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INSTRUCTION MANUAL
FOR
REGULATED POWER SUPPLY

MODEL TVR 040-15

CAL-POWER CORPORATION
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GENERAL INFORMATION

Perkin Model No. TVR040-15 D.C. Power Supply was designed to meet the most stringent requirements in terms of stability and specifications. This unit is equally well-suited for laboratory bench use or system application and installation. Tests and measurements can be made automatically at different voltages using automatic voltage programming. A current-limiting circuit, is incorporated in the unit to protect against over loading or short-circuit condition. The range of the current limiting control is 0-18 amps. A. D.C. voltmeter, a D.C. ammeter and all of the foregoing controls are mounted on the front panel, which make them easily accessible to the operator. The output or the power supply is ''floating'' so that either positive or negative terminal may be grounded. The unit is well suited for bench mounting and is provided with adapters making it suitable for mounting and is provided with adapters making it suitable for mounting in a standard 19'' wide rack. A special feature of the power supply is the single control printed circuit control board of the plug-in type which is interchangeable with all Perkin TVR and TVCR line D.C. Power Supplies.

INTERPRETATION OF REGULATION

Regulation is expressed as $\pm$ X% about an arbitrary instead of a specific reference.

It is feasible that this tolerance can be either all positive or all negative from the arbitrary reference selected. In other words, it is possible to select a reference point for any given power supply around which the regulation will be $=$ X%. Conceivably, this point may occur anywhere from no-load to full-load, or anywhere from low-line to high-line. This interpretation will mean that the output voltage will be held within an envelope of two times X%.

MEASUREMENT OF REGULATION

All Perkin TVR and TVCR model power supplies have precision regulation in the order of a few millivolts. It is, therefore, important to observe proper connection of measuring instrument. If the measuring instrument is improperly connected voltage drops in the leads will cause poor regulation. Make regulation measurement in the following manner:

1. For rear-terminal connection, connect the load across terminal 2 and 5 on TB1 (2 is positive) and connect the measuring instrument across terminal 3 and 4 on TB1 (3 is positive).
2. For front panel connection, connect the load across the terminals (red is positive) and connect the measuring instrument across these terminals (see figure A). This method of connection avoids the unnecessary voltage drops in the leads.

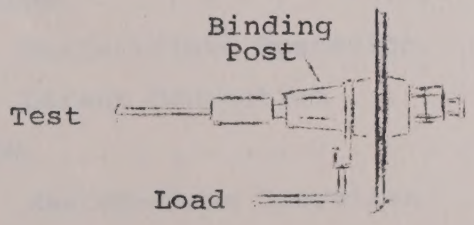

Figure A

3. When operating in the remote sense mode, refer to ''Remote Sensing'', page 7 for proper connection.

NOTE: In the event accurate measurements are required, such as in calibration, the rear terminal connection is recommended.

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OPERATING INSTRUCTIONS

FOR

MODEL TVRC40-15 REGULATED POWER SUPPLY

I SPECIFICATIONS

A. Electrical

D.C. Voltage Range:	0-40 Volts
D.C. Current:	0-15 Amps
A.C. Input:	105-125, 1 phase, 57-63 cps, 14 amperes.
Static Line Regulation:	±0.01% or ± 2MV
Static Load Regulation:	±0.02% or ± 4MV
Dynamic Line Regulation:	± 25MV for ± 10 VAC Step Change.
Dynamic Load Regulation:	± 0.25 for NL to FL Step Change.
Ripple and Noise:	1MV RMS (Voltage)
Response Time:	50 Microseconds.
Temperature Coefficient:	± 0.02% or ± 4 MV/°C
Stability:	± 0.1% or ± 20 MV at constant ambient for 8 hours after 20 minutes warm-up (with precision programming resistor).
Remote Programming Constants:	100 ohms/volts (Voltage)
Remote Programming Accuracy:	± .25% or ± 75MV
Output Impedance:	2 milliohm max. at D.C. 10 milliohm max. DC. -1KC 100 milliohm max. 1KC-20KC 200 milliohm max. [illegible] 20KC - 500KC

A. Electrical (cont.)

Limit Controls:	Current, 0-18 ADC
Resolution of front panel fine controls:	10MV (voltage) (If better resolution is required, use remote program connections.)
Meters:	Voltage, 0-50 VDC ± 2% Accuracy Current, 0-20 ADC ± 2% Accuracy

B. Other Specifications

Mounting:	Completely enclosed for bench mounting. Unit is provided with adapter for 19" rack mounting.
Dimensions:	Width: 17" (bench), 19" rack Depth: 21" behind front panel including terminals on rear. Height: 7"
Weight:	60 pounds
Terminals:	A.C. Input: Terminal Strip (No. 8 screws) on rear. D.C. Output: Terminal Strip (No. 8 screws) on rear, and 5-way terminals on front panel. Remote Connections: Terminal Strip (No. 8 screws) on rear.
Maximum Ambient Temperature:	45°C.

II INSTALLATION

The power supply should be mounted with clearance of at least 2" on either side, so that the flow of cooling air is not restricted.

If the power supply is to be rack-mounted, the two rack adapters supplied with the power supply should be mounted on either side of the power supply with the screws already in place.

The AC input should be connected to terminal strip TB2, terminals 1 and 2. The AC input should be as specified herein. Terminal No. 3 on TB2 is a chassis ground and should be connected to the power system ground.

The load should be connected to TB1 or to the front panel terminals. See connection on Figure 1 for proper terminals on TB1.

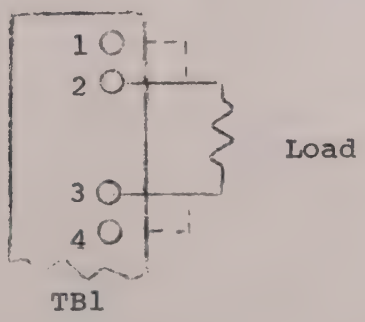


Figure 1 - Load Connection

III OPERATING INSTRUCTIONS

A. Turn-On Operation

1. The AC input switch (S1) should be placed in the "ON" position. The AC input light (DS1) should light indicating the presence of the AC input power.
2. The desired output voltage should be adjusted by means of the coarse voltage adjust (R8) and the fine voltage adjust (R9). The range of the fine voltage control is approximately 0.5 volts.
3. The desired current limit should be set by means of the current limit adjust (R22).

NOTE: This power supply is shipped from the factory with the rear terminal connected as shown in the figure below. Before turning on the unit, make sure that all the jumpers are in their proper places.

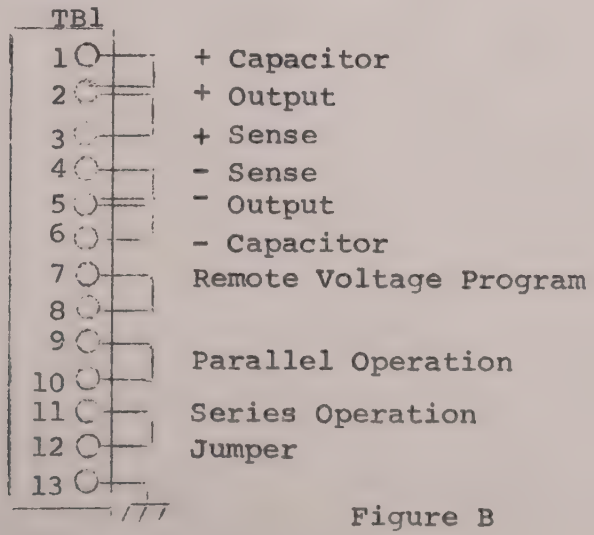


Figure B

ADDENDUM

CAUTION

Precuation must be taken that the remote program jumper on the rear terminal of all TVR and TVCR models must be secure in its place before applying input power to the unit.

Remote voltage program connection must be done with the AC input power in the "OFF" condition. Failure in taking the above precaution may damage the unit.

B. Remote Voltage Programming

This feature provides adjustment of output voltage from a remote point. The voltage can be adjusted (or programmed) from 0-40 volts. In the remote voltage programming mode, the fine and coarse voltage controls are disabled.

To program a voltage output, remove jumper 7-8 on terminal strip TB1 (See Schematic). Then connect the programming resistor between terminals 8 and 3. The programming constant is 100 ohm/volt; e.g., 20 volt output required: 20 x 100 ohms = 2000 ohms.

In the event programming of voltage over a narrow range is desired than 2 resistors (one adjustable and one fixed) should be connected between rear terminals 3 and 8, Figure 2 (after jumpers 7-8 are removed) as follows: Assume a voltage range of 24-32V is des then calling V_1 = low voltage and V_2 = high voltage range, $R_1 = V_2 - V_1 \times 100$ (ohms/volt) = 8 x 100 = 800 ohms. $R_2 = V_1 \times 100 = 24 \times 100 = 2400$ ohms. The curr current in the programming resistor is 10 MA. The maximum power in the resistor for 40 volt output is 40 x .010 = 0.4 watts.

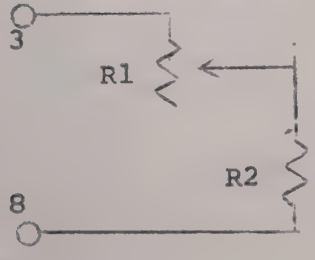


Figure 2

In the event full wide range (0-40V) control is desired, a resistor or a linear pot of 40 x 100 (ohms/volt) = 4000 ohms should be used.

If it is desired to program the voltage in steps, assume 4 steps at 10V, 20V, 30V, and 40V; a shorting type switch should be used in the connection as shown in Figure 3. The effect will be as shown in Figure 4.

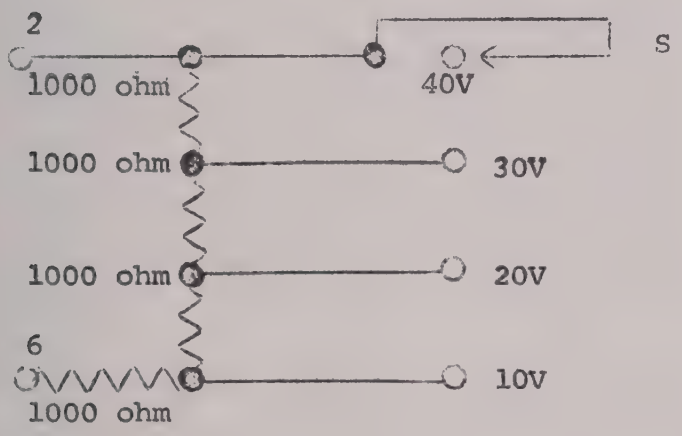


Figure 3

Figure 4

(NOTE: It is not recommended to reduce the voltage over 20 volts in one step, but it may be increased the entire 40V in one step.)

C. Remote Sensing

Remote sensing is provided to regulate out the voltage drop in the load leads. To use remote sensing, remove the jumpers between 2 and 3 and 4 and 5 on TB1. A lead from terminal 3 should be connected to the positive end of the load. A lead from terminal 4 should be connected to the positive end of the load. A lead from terminal 4 should be connected to the negative end of the load. The resistance of each remote sense lead should not exceed 1 ohm. The sense leads should be twisted for short runs and shielded-twisted for long runs.

If a remote sense lead is accidentally removed, voltage regulation atuomatically reverts to local sense (the power supply output terminals). There is one volt shift upward when this occurs (for each sense lead removed).

D. Output Capacitor Connection

When using remote voltage sensing, the output capacitor C5 should be connected directly across the load as follows: Remove jumpers 1 and 2 and 5 and 6 on TB1. For short load cables, connect a lead from terminal #1 on TB1 to the positive end of lead and a lead from terminal # 6 on TB1 to the negative end of the load. The capacitor leads should be at least 10 guage for distance up to 10 feet. For distances greater than 10 feet, s separate capacitor (8,000 - 10,000 MFD at

50 VDC) should be connected directly across the load terminals. The preceding procedure will insure good dynamic regulation at the load.

When remote voltage sensing, the voltage drop in the negative load lead causes the calibration of the current limit adjustment to change slightly. The unit will current limit sooner when remote sensing. If the maximum current limit setting is required under these conditions, it is necessary to adjust R24.

IV CALIBRATIONS

A. Pre-Regulator (See Figure 5 on page 10 for location of adjustment.)

The unit should be operated with an output voltage setting of 20V and with no-load. A DC voltmeter should be connected across terminals 4 and 5 on TB301. The positive of the meter connects to terminal 5. The pre-regulator sense adjustment (R29) is adjusted until the voltage reads on the meter 16V ± 0.5V. The power supply is loaded to full-load of 15 amperes and the pre-regulator reference adjustment (R12) is adjusted until the voltage is 5V ± 0.25V. Since these two adjustments interact, the unit should be operated alternately at no-load and full-load until proper voltage levels are obtained.

B. Printed Circuit Control (See Photo 4)

The calibration of the control board must be made in the following sequence with the power supply operating in the voltage mode with a remote program resistance of 2000 ohms ± 0.1%.

1. Connect a voltmeter across R107 (261 ohms) and adjust the auxiliary volt adjust (R121) until the voltage across R107 is 5.74V ± 0.05V.
2. Monitor output voltage of unit with a differential voltmeter Fluke Model 801 or equivalent. Adjust the load compensation adjust (R117) until the no

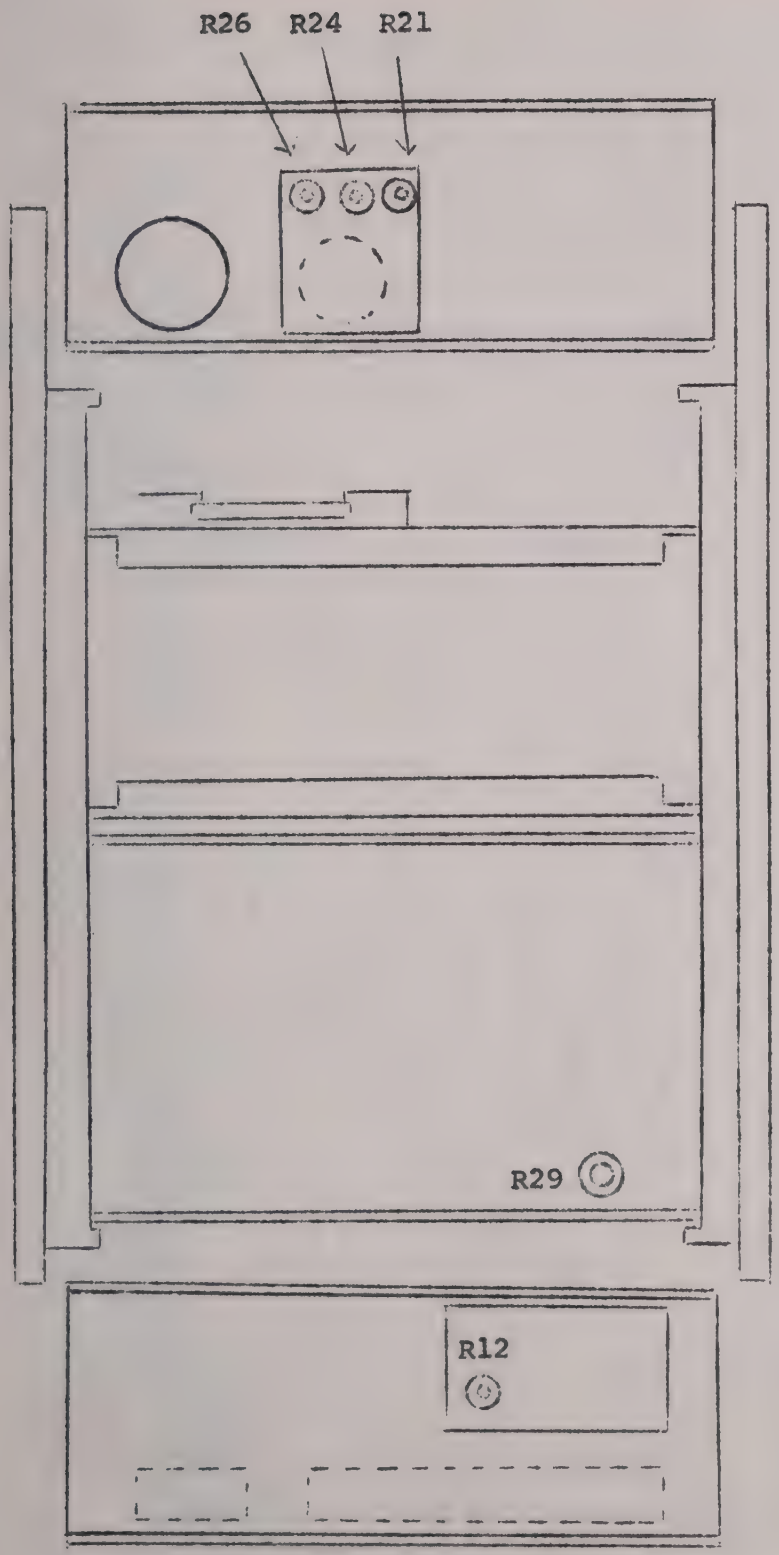


Figure 5 - PRE-REGULATOR CALIBRATION ADJUSTMENT

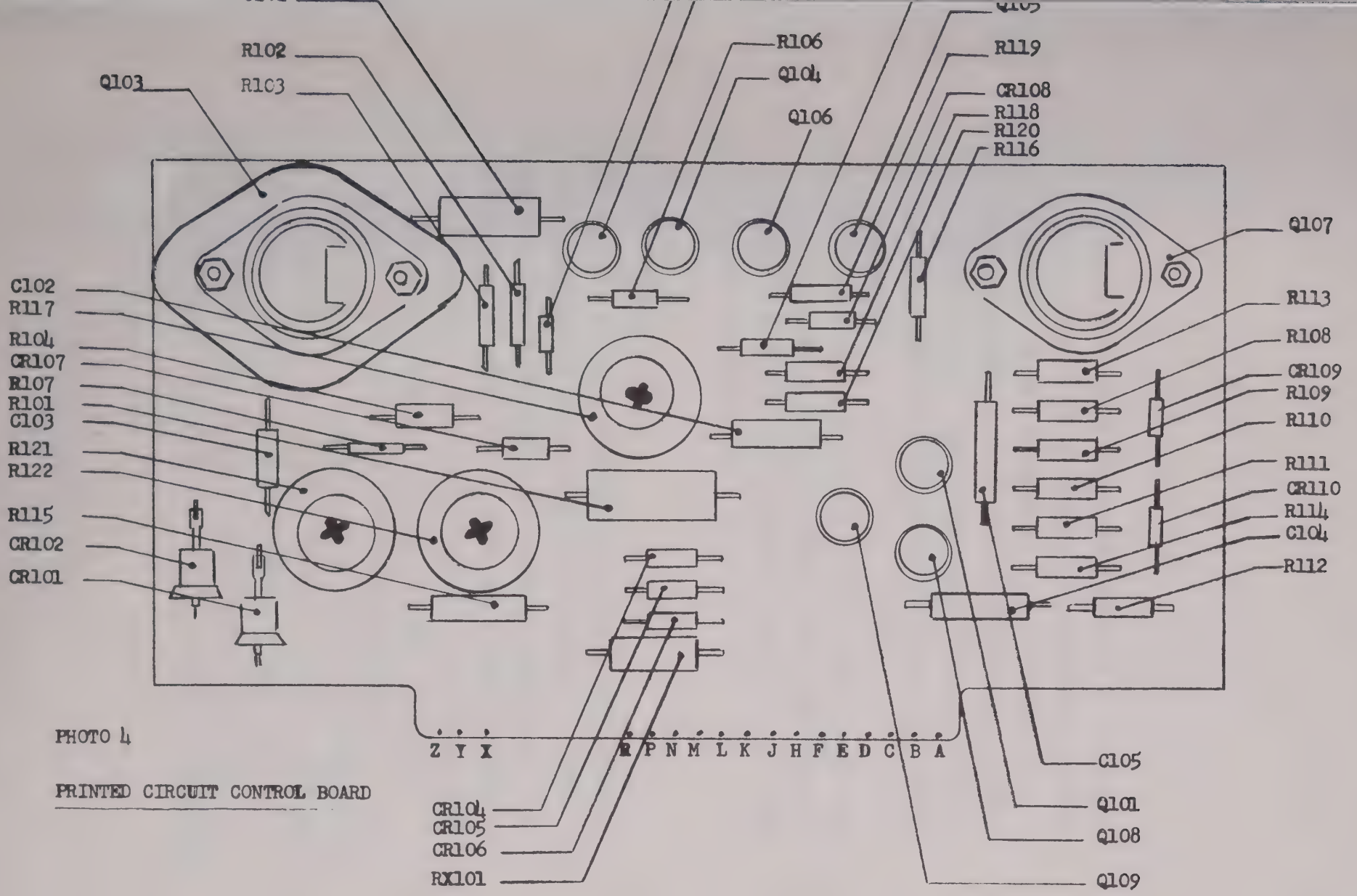


PHOTO 4

PRINTED CIRCUIT CONTROL BOARD

load to full load regulation (0-15A) is less than 1 millivolt. The differential voltmeter must be connected across terminals 3 and 4 on TB1 (3 is positive) and the load connected across terminals 2 and 5 on TB1. This method of connection will elimate metering errors when measuring the load regulation.

3. With no load on the unit, adjust the voltage program calibration adjust (R122) until the output voltage is 20V ± 0.005 volts as read on the differential voltmeter.

C. Current Limit

The purpose of this feature is to limit the current under overload or short-circuit conditions. Under short-circuit condition, the current remains at the maximum setting and the voltage goes down to zero volt. When the short-circuit condition is removed, the voltage and current return to their original condition. Calibrate in the following manner:

With the power supply operating at load condition, adjust the current limit control (R22) to the maximum clockwise position. Short circuit the unit and adjust the current limit calibration adjust (R24) until the output current is 18 amperes ±0.5A.

V PARALLEL OPERATION

In the event higher current output is required than the unit can supply, parallel operation is recommended. Two methods of parallel operation are possible:

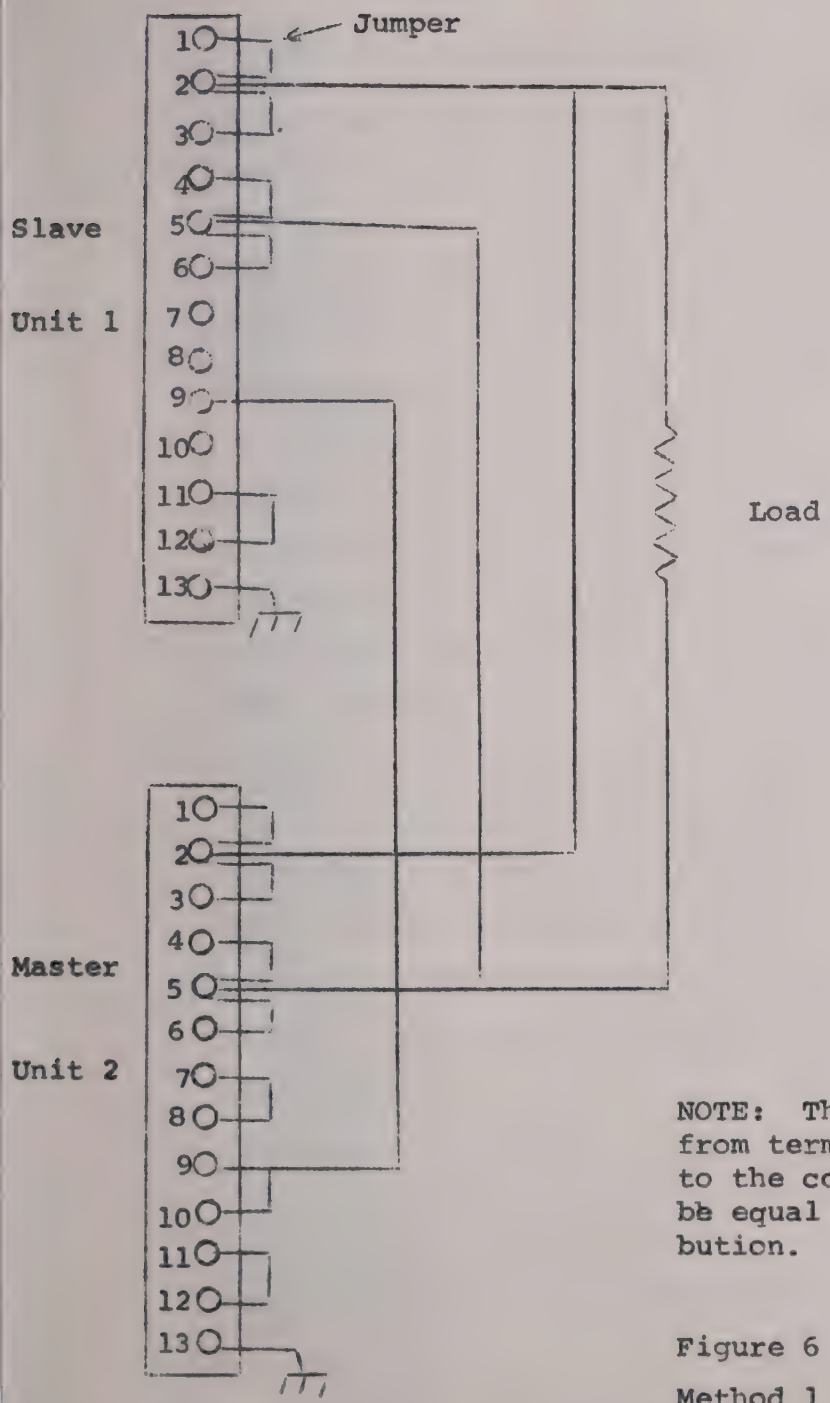
A. Method I: Master-Slave Operation

The advantages of this method is that the voltage regulation is the composite supply is essentially the same as that of a single supply. The composite unit is essentially a single unit, in a sense that it can be controlled by one power supply - the master unit.

The first method of parallel operation consists of driving both units' power transistors from one unit, the master unit. The voltage adjustment and current limit setting are made on the master unit only. The current limit scale must be multiplied by the number of units in parallel. Connections should be made as shown in the Figure 6.

The connection is shown for local sensing. If remote sensing is required, remote sensing connection should be made to unit 2 only (master unit). The voltage adjustment is also made from the master unit since it is controlling unit 1 (slave unit).

CAUTION - DO NOT OPERATE UNITS IN PARALLEL UNLESS ALL UNITS ARE ENERGIZED. ALL UNITS IN PARALLEL SHOULD BE TURNED ON AND OFF AT THE SAME TIME.



NOTE: The lead resistance from terminal 5 of each unit to the common junction should be equal for best load distribution.

Figure 6 - PARALLEL OPERATION

Method 1 - Master-Slave Operation.

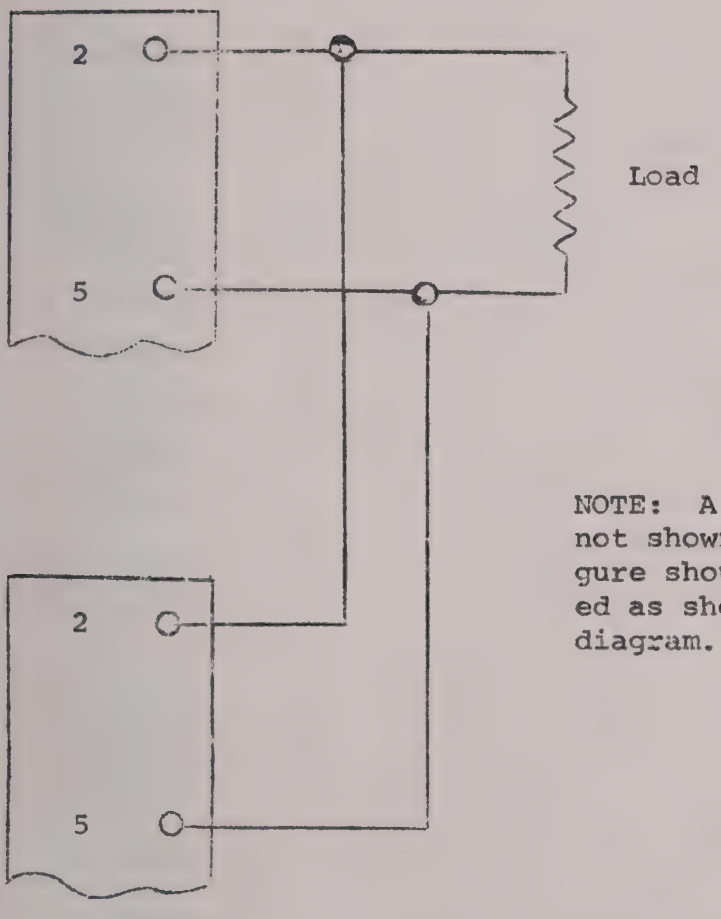
B. Method II: Direct Connection

The second method consists of simply paralleling the two units as follows: Directly connect the positive terminal (2) TB1 of one unit to the positive terminal (2) TB1 of the other unit and terminal (5) TB1 of the unit to terminal (5) TB1 of the other unit (Figure 7).

The voltage of both units must be adjusted as closely as possible to the same voltage. The unit with slightly higher voltage will supply the load until it current limits. When this occurs the voltage will drop slightly to the level of the second unit and it will supply additional load current up to its current limit setting.

The total regulation will be $VR_T = V_2 - V_1 + VR_1$ where:
VR_1 = voltage regulation of first unit in volts.
V_1 = output voltage of first unit.
V_2 = output voltage of second unit (assumed higher).

Using this method, any number of units can be paralleled. The formula for any number of units in parallel becomes:
$VR_T = V_N - V_1 + VR_1$
VR_1 = voltage regulation of the lowest unit in volts.
V_1 = output setting of the lowest unit.
V_N = output setting of the highest unit.



NOTE: All terminals not shown in this figure should be connected as shown in Schematic diagram.

Figure 7 - Parallel Operation
Method II - Direct Connection

VI SERIES OPERATION

In the event higher voltage output is required than a single unit can supply, series operation is recommended. Two methods of series operation are possible:

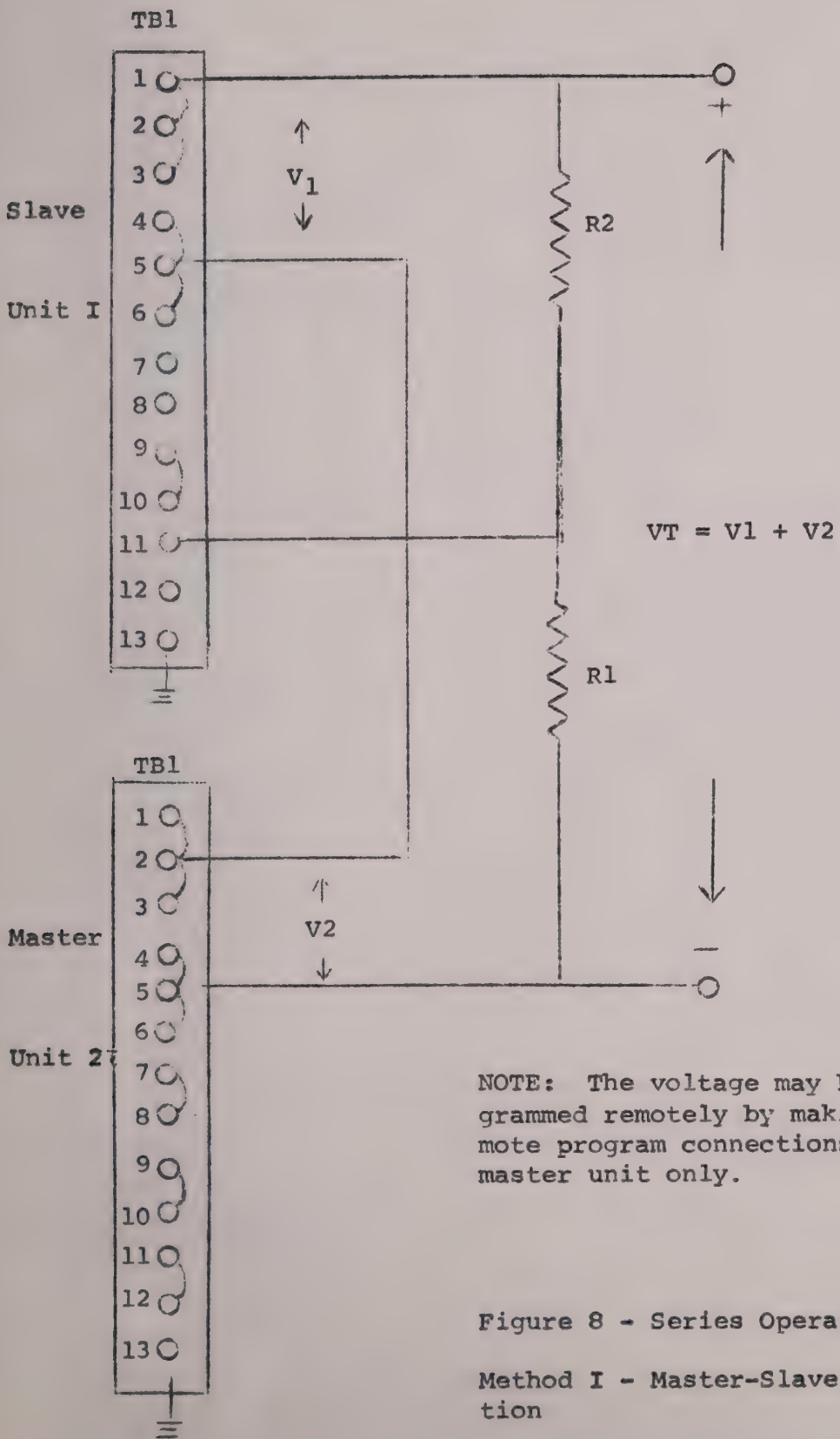
A. Method I: Master-Slave Operation

In this method, it is possible to adjust the output voltage using the front panel voltage control knob on the master unit. The control circuits of the slave units are inoperative and all the slave units use the control of the master unit. This connection can be used for any number of units connected in series up to 10 maximum due to insulation breakdown requirements. The current limiting control for all units should be adjusted to the same value so that the output for all units will collapse at approximately the same time (See Figure 8 and 9).

$V_2 = V_1 \frac{R_2}{R_1}$ (In reference to Figure 8)

The voltage coarse and fine control have no effect on the slave unit. When the voltage level is changed on the master unit, the slave will also change to maintain voltage as given by the formula.

$R_1 + R_2$ should be chosen to allow approximately 10 ma to flow through them or approximately 100 ohm/volts across them.



NOTE: The voltage may be programmed remotely by making remote program connections on the master unit only.

Figure 8 - Series Operation

Method I - Master-Slave Operation

THREE UNITS IN SERIES

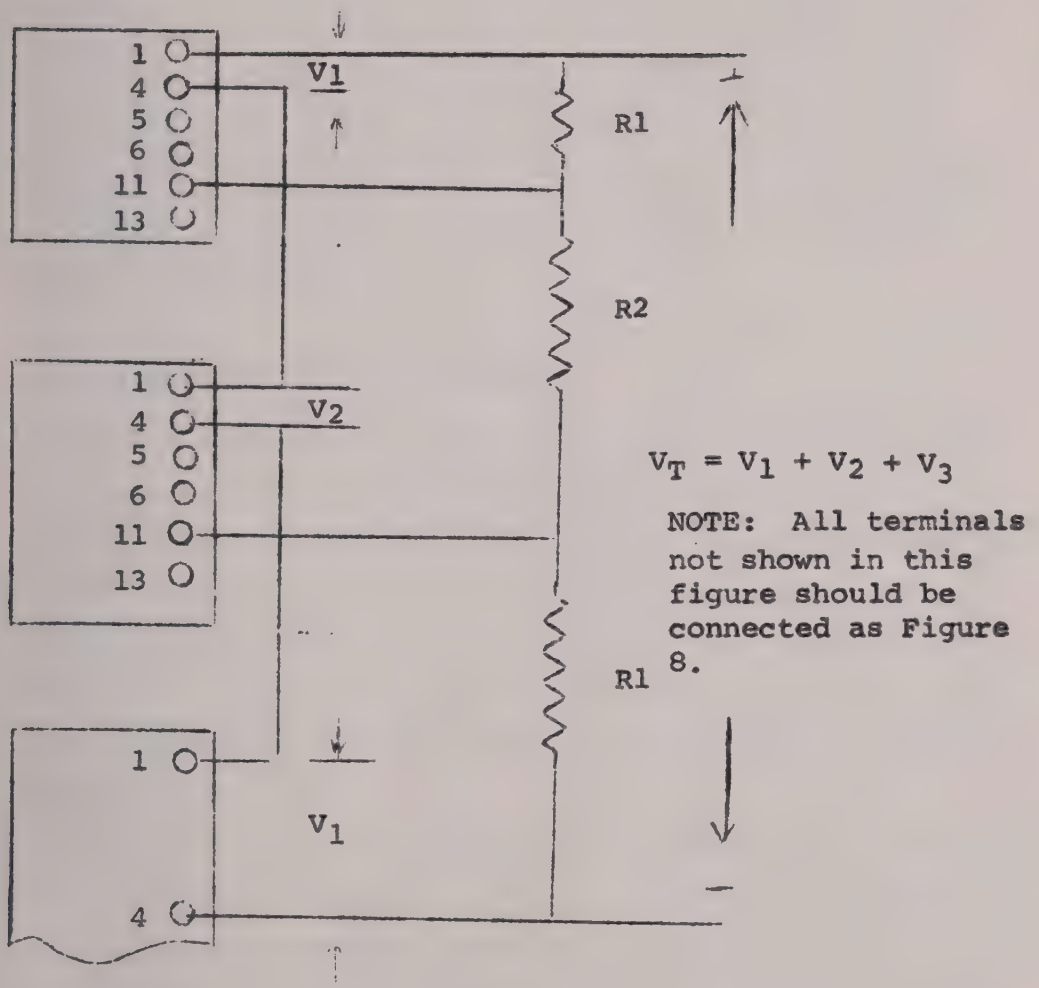


Figure 9 - Series Operation

Method I - Master-Slave Operation

$$V_2 = V_1 \frac{R2}{R1}$$

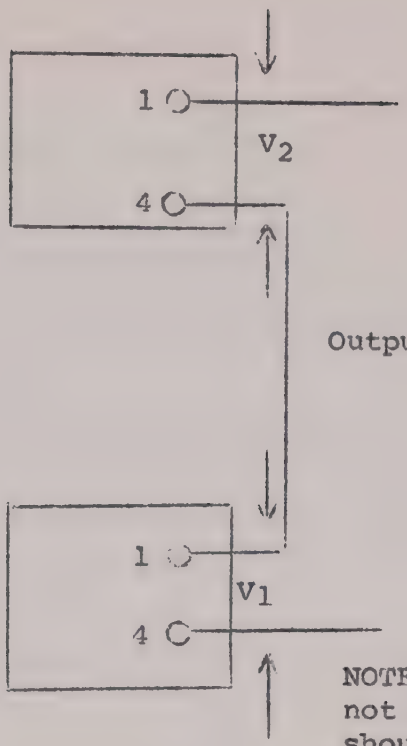
$$V_3 + (V_1 + V_2) \frac{R3}{R1 + R2}$$

It is possible to use this set-up for as many as ten units by extrapolating the formula. The front panel control in place of resistor R_3 may be used by re-installing the jumper between terminals 7 and 8. Then set the desired value by use of the front panel control. Once this control has been set, it should not be re-adjusted.

B. Method II: Direct Connection

Directly connect the positive terminal (1) of one unit to the negative (4) of another (See Figure 10). Total output = $V_1 + V_2$. The current limiting controls on both units should be set to the same point for normal operation. It is possible to get a two-step (or more depending on number of units in series) voltage pattern by following the procedure outlined below. (See Figure 11.)

1. Adjust one power supply output voltage to value V_1 and set its current limit to the maximum current level requirement (in example, 40V and 5A).
2. Adjust second power supply to value V_2 and adjust the current where voltage step is desired (in example 40V and 2A).



NOTE: All Terminals not shown in this figure should be connected as shown in schematic dia.

Figure 10 -
Method II - Direct Connection

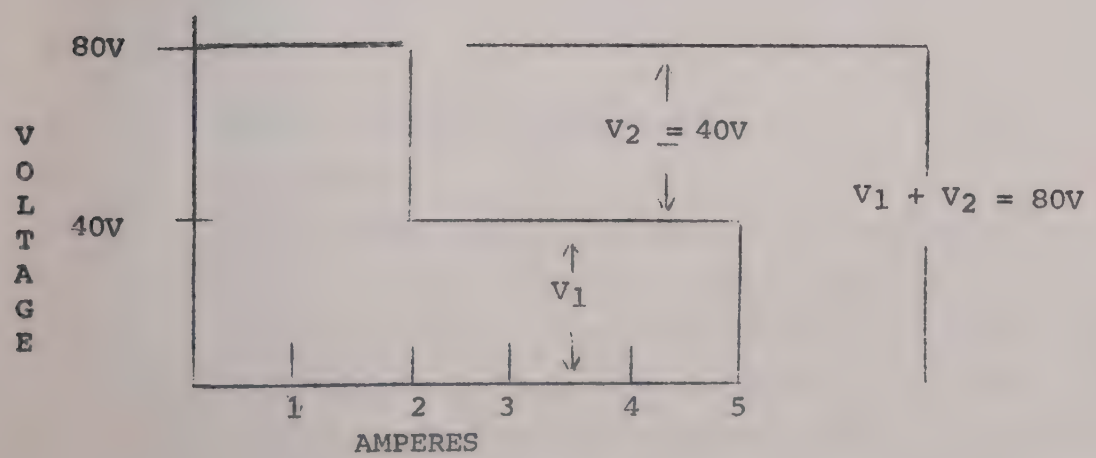


Figure 11

VII SERVICING

A. Instrument and Test Readings

To obtain accurate readings, the following instruments are recommended:

1. Voltmeter: 20,000 ohm/volt ± 1.5% accuracy on D.C. (Triplett Model 630 NA or equivalent.)
2. Differential Voltmeter: Fluke Differential Voltmeter.
3. Oscilloscope: Hewlett Packard Model 130B or equivalent.

Typical voltage readings taken under test conditions are as follows:

AC Input	115VAC
DC Output Voltage	20VDC
DC Output Current	15A

Refer to Schematic Diagram 5614 for location of test points listed in Table 1, pages 28, 29, 30.

B. Trouble Shooting Instructions

1. General

The power supply incorporated two complete regulators. One is termed the pre-regulator and consists of silicon controlled rectifiers (SCR301 and SCR302) and the magnetic firing circuit part number 5528. The other is the series transistor regulator which consists of the power transistor section (Q301-Q303),

the driver transistor (Q304), and the printed circuit control part No. 5530.

The function of the pre-regulator is to regulate the voltage across the series power transistor. The voltage across these transistors is constant within ± 5%, or better, for line changes or output setting changes - providing the load current remains constant. The magnitude of this voltage varies with the load, current being 16 volts at no load and 5 volts at full load.

2. Localizing the Trouble Area

If a malfunction develops, the trouble area may be localized by the following manner:

NOTE: The unit should be operated at no load condition.

a. Remove the printed circuit control board.
b. Place insulation between the normally closed contacts relay K1.
c. Slowly increase AC input voltage with a variable voltage transformer.
d. Observe voltage across terminals 4 and 5 on TB 301 (large terminal strip on semiconductor assembly). Positive of meter should be on terminal 5. As the AC input is increased, the voltage reading should slowly increase until approximately 16 volts is reached; after this voltage should remain constant across terminals 4 and 5.
e. If the voltage increases across the output term-

inals of the power supply instead of the power transistor as mentioned in step "d", the trouble is probably a defective power transistor. If the conditions are as outlined in step 4, after defective transistor is located, replace transistor.

f. If the voltage comes up across the transistors (step "d") but does not level off at 16V, there is trouble in the pre-regulator.

g. If the conditions in step "d" are achieved and the power supply will not operate properly when the PC board is replaced, the trouble is probably in the PC board itself. The board should be replaced with one know to be in good order.

3. Remedy

a. Pre-Regulator

When trouble develops in the pre-regulator section, the magnetic firing circuit (Part No. 5528 - the green box) and the sense current limiting circuit (Q1 and its associated components) should be checked.

The magnetic firing circuit can be checked by observing the output wave form on the oscilloscope. The correct wave forms and the test numbers are given in Figure 12. If these wave forms are not obtained, the magnetic firing circuit is defective and it should be replaced

Figure 12

Firing Circuit Output Wave Form
Measured under Standard Test conditions, page 21, Top Trace measured between test points 40 and 41, Negative on 40.
Bottom Trace measured between test points 40 and 42, negative on 40.
Vertical Sensitivity 1V/CM
Horizontal Sensitivity 5 Msec/CM

with one known to be in good order.

Check the sense current limiting circuit in the following manner:

1. Measure the voltage between collector and emitter of Q1 (test points 38 (positive) and 39. The voltage should be .015 - .020 volt).
2. Measure the voltage between base and emitter Q1 (test points 38 (positive) and 37). The reading should be 0.1V - 0.2V.
3. If these readings are not obtained, the transistor Q1 and/or its associate components may be defective.

b. Transistor Series Regulator

When the transistor assembly is suspected for causing the malfunction, the power transistors Q301, Q302, and Q303 should be checked for short. This check can be quickly done by measuring the collector to emitter resistance (test points 45 and 55). Replace the defective transistor. The distribution of current through the individual power transistors can be measured by operating the unit at 15 amperes load and measuring the voltage drop across each of the emitters resistors (R303-R305) located on top of the regulator assembly. The voltage drop should be 1.03 $\pm$ 0.2V across each of the three resistors. In case of a failure of the

cooling fan, the semiconductors in the assembly will over-heat if the unit is operated at high load current or high ambient temperatures. To prevent damages under these conditions, a thermo-switch (S301) is incorporated to open the base drive circuit and cause the output voltage to be terminated. When the thermo-switch cools, the output will automatically turn on.

c. Printed Circuit Control

Failure of the output voltage is usually caused by the defective printed circuit control. The simplest remedy is to replace it with a new one. If replacement is not available, check the printed control board in the following manner:

1. Measure the output voltage of the auxiliary regulated power supply across C101 (test point 7 and 3). The reading should be 17.1V - 18.0V.
2. If step 1 is in good order disconnect terminal 7 on TB302 and insert an ammeter in series with it. The current should read 10 ma - 20 ma.
3. When step 1 and step 2 are in good order, the trouble is located somewhere else. Check in the following manner:

i. Measure the voltage of 9-11V across the zener diode CR7 (test points 55 and 34, negative on tt). Replace if defective.

ii. Check the voltage adjust potentiometer (R8) for short. Replace if defective.

TABLE 1

VOLTAGE REGULATION D.C. READINGS

Negative Test Point	Positive Test Point	D.C. Volts	Tolerance	Remarks
1	2	0.8		
2	4	15.6		
4	5	0.8		
4	6	0.7		
2	3	16.4		
2	7	33.7		
10	7	2.5		
9	10	9.18	8.9-9.7	
3	9	5.72	5.69-5.79	Differential Voltmeter
8	9	0.08		
9	15	9.1		
3	19	4.06		
3	10	14.9	14.6-15.5	
3	8	5.64		
3	7	17.4	17.1-18.0	
19	18	9.2		
18	17	1.6		
21	22	0.74		
20	25	0.05		
23	25	0.15		
11	21	3.7		

Negative Test Point	Positive Test Point	D.C. Volts	Tolerance	Remarks
11	21	3.7		
11	12	0.15		
11	13	8.0		
24	13	2.4		
14	24	0.14		
15	24	0.16		
16	24	2.1		
12	24	5.5		
14	10	0.03		
53	52	0.19		
55	33	41.5		
35	55	39.5		
55	34	10.9	9-11	
38	55	0.18		
37	38	0.16		
39	38	0.015		
55	36	7.8		
43	39	4.0		
45	55	5.0	5.25-4.75	
17	34	13.5		
17	15	2.6		
49	44	20.0		
56	55	1.0	0.8-1.2	

Negative Test Point	Positive Test Point	A.C. Volts	Tolerance	Remarks
54	55	32		
55	48	32		
26	27	11		
30	31	26		
31	33	26		
28	29	68		
46	47	115		